AD-A082 520 NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA COMMUNICA--ETC F/G 17/2
PERFORMANCE OF INDUSTRIAL TV CAMERAS IN THE NAVY PHYSICAL SECUR--ETC(U)
1980 H J HAYES, T J BOYCE

UNCLASSIFIED NADC-80010-40 NL

1 OF 1
AD A
082520

END
DATE
FILMED
5-80
DTIC

REPORT NO. NADC-80010-40

LEVEL II

(12)

PERFORMANCE OF INDUSTRIAL TV CAMERAS IN THE NAVY PHYSICAL SECURITY PROGRAM

Henry J. Hayes and Theodore J. Boyce
Communication Navigation Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

FINAL REPORT
NAVELEX WORK REQUEST NO. WR95177
Work Unit No. AD301

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

Prepared for
NAVAL ELECTRONICS SYSTEMS COMMAND
Department of the Navy
Washington, DC 20360

NOTICES

REPORT NUMBERING SYSTEM - The numbering of technical project reports issued by the Naval Air Development Center is arranged for specific identification purposes. Each number consists of the Center acronym, the calendar year in which the number was assigned, the sequence number of the report within the specific calendar year, and the official 2-digit correspondence code of the Command Office or the Functional Directorate responsible for the report. For example: Report No. NADC-78015-20 indicates the fifteeth Center report for the year 1978, and prepared by the Systems Directorate. The numerical codes are as follows:

CODE	OFFICE OR DIRECTORATE
00	Commander, Naval Air Development Center
01	Technical Director, Naval Air Development Center
02	Comptroller
10	Directorate Command Projects
20	Systems Directorate
30	Sensors & Avionics Technology Directorate
40	Communication & Navigation Technology Directorate
50	Software Computer Directorate
60	Aircraft & Crew Systems Technology Directorate
70	Planning Assessment Resources
80	Engineering Support Group

PRODUCT ENDORSEMENT - The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

APPROVED BY: William F. Lyons Jr. DATE: 2-26-80

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 14 NADC-80010-40	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 Performance of Industrial TV Cameras In The Navy Physical Security Program		5. TYPE OF REPORT & PERIOD COVERED 9 FINAL rept.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Henry J. Hayes [redacted] Theodore J. Boyce		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Communications Navigation Technology Directorate Naval Air Development Center - Code 4044 Warminster, PA 18974		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NAVELEX Work Request No. WR95177
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Electronics Systems Command Department of the Navy Washington, DC 20360		12. REPORT DATE
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 11 1980		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited. 12 26

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Appendices A, B, and C.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

TV Cameras
Image Conversion Requirements
Camera Imaging Performance & Deficiencies

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A summary of technical work resulting from the purchase and maintenance of TV cameras for Navy Physical Security use. The camera image conversion requirements deemed necessary for the application are stated in the procurement specification. The image analysis incoming inspection tests that were developed to monitor performance of production cameras are discussed. Technical improvements resulting from this work and the performance deficiencies still encountered give an overview of industrial TV cameras used in a demanding application.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

UNCLASSIFIED 393533

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

TABLE OF CONTENTS

INTRODUCTION

The procurement specification developed on the project for the purchase of TV cameras for Navy Physical Security use reflects state-of-the-art performance of an automatic, low-cost TV camera. The report shows the need for consistent, high-performance pictures and the imagery deficiencies experienced with cameras manufactured by the best available industrial type camera companies.

The camera industry is small and marketing of industrial cameras is nontechnical because nontechnical users buy cameras. Most industrial users requirements are not as defined or as severe as the Navy Physical Security need. The report presents the results of the analysis and testing done at NAVAIRDEVCEN to determine the detailed reasons for poor performance in cameras giving poor pictures. These reasons were explained to the camera manufacturers so that improvements could be made. The work helped the industrial TV camera industry.

PROGRAM BACKGROUND

Work was tasked by NAVELEX (PME-121) to NAVAIRDEVCEN to evaluate and purchase suitable, off-the-shelf, commercial TV security cameras for use in a physical security program. These cameras are intended to be the best interim devices available and used until the Air Force Base Intrusion Security System (AFBISS) program develops suitable MIL SPEC cameras. The function of the cameras is to provide high-quality images of security fence lines. The pictures will permit an assessment of causes of sensor alarms. The cameras must be completely automatic providing video signals to the monitors for adjustment-free operation by the observer. Cameras must work in a light range of less than 0.005 FC to greater than 10,000 FC and with wide contrast range in outdoor environments at almost any location in the world.

The assessment of action responsible for a perimeter alarm depends on the experience and judgement of the observer, the field of view contained in the scene, and the quality of the reproduced picture. The amount of picture detail that can be seen by the observer is inversely proportional to the size of the action producing the alarm. Detailed perception is a function of system contrast and resolution.

The criteria used in imaging the smallest action size for observation is the width of a man (24 in.) divided into 8 picture elements; that makes a picture element 3 in. Experiments conducted by the Army Night Vision Laboratories concluded that 8 picture elements are sufficient for the identity of a man from other possible objects. The cameras are spaced along the fence so that images beyond a range that reduces a picture element to 3 in. are not used. As an example of maximum usable range, assume 600-line resolution in an image obtained from a 75-mm lens at 900 ft. range, the image width is 150 ft.; so

$$\frac{150 \text{ ft.} \times 12 \text{ in.}}{600} = 3 \text{ in. picture element.}$$

A picture element is 3 in. at a range of 900 ft.

A camera performance study task was initiated to enable the Navy to purchase the most cost effective cameras available for the job. It was learned that commercial TV security cameras are used by nontechnically oriented customers and the industry marketing is geared to that condition. The NAVAIRDEVCEN incoming inspection of camera performance showed that production cameras are made with wide variations in characteristics. Cameras from the industry are normally sold by a set of specifications that describe nearly the best performance possible for that type camera. Industry marketing normally determines whether a camera application requires an above or below average camera. The large performance variations in normal production can be tolerated by selecting cameras in small lot installations.

Because there are many details to the description of picture quality, and in order to describe picture quality in relation to measurable camera parameters, technical innovation work was necessary. This work required defining, measuring, and analyzing image characteristics in relation to security requirements and the development of a performance specification. It was also found necessary for NAVAIRDEVCEN to inform the manufacturer with almost continuous information on detailed incoming inspection performance faults in order that corrective action at the plant could be identified.

As a program summary, the following performance improvements are positive, identifiable gains for the industrial TV camera industry resulting from work initiated on this program. Imaging characteristics developed from camera performance analysis at NAVAIRDEVCEN for the procurement specification, along with the impetus provided by a rather large future camera procurement, resulted in the following camera image conversion improvements:

The range of controlled video signals has been extended to lower light levels on the vidicon. This improvement eliminates adjustment of the picture monitor by the observer so as to retain a high-contrast picture when the light on the vidicon face plate falls below 0.05 FC to the threshold of the vidicon.

Black level clamping performance greatly improved. This feature eliminates adjustment of the picture monitor by the observer to maintain contrast with changes in Average Picture Level (APL).

Gamma control improved. This reproduces the same areas of a scene with identical contrast when the scene is imaged with any camera.

Improved capability of the camera to reproduce usable images and without the need for adjustment of the picture monitor when the scene contains small bright areas, such as car headlights, or with fast, step function lighting changes.

Vidicon beam current automatically controlled to the optimum value. This prevents beam current drift with tube aging and external heat. There is no picture "wipe out" caused by environmental conditions until the vidicon emission fails.

CAMERA REQUIREMENTS

Camera specifications from the half dozen prime camera manufacturers were analyzed early in the program. The analysis defined the maximum claimed performance of the off-the-shelf product. There was little information on camera Mean Time Between Failures (MTBF) at the time. It has been found that the MTBF on an average is low; between 1500 and 5000 hours. With this MTBF range in a 20-camera installation, 10 to 3 camera changes per month are required in maintenance.

Anticipated camera performance characteristics developed in the preliminary analysis were used to define physical security lighting levels, camera field-of-view foot prints and input data to Base Intrusion Security System (BISS) to tighten the required performance of the proposed BISS camera. The information also was responsible for the development of a realistic procurement specification (appendix A) for use in obtaining competitive bids on the camera purchases. The specification identifies performance measurements for critical acceptance parameters.

The result with the bidding was that company marketing did not appreciate the problems of being held to a specification because of the nontechnical sales approach. Factory tests on finished cameras were insufficient to identify out-of-spec performance. The NAVAIRDEVCEN was required to devise tests and make measurements on every camera in order to accept only cameras meeting specifications; those producing acceptable pictures in "all use" conditions. It was found that the performance of the average production camera delivered to NAVAIRDEVCEN was below the performance required and identified in the purchase specification.

CAMERA PERFORMANCE PROBLEMS AND CORRECTIONS

There were many reasons that caused poor performance in the cameras, and each problem was thoroughly investigated at some time during the project. The problems are discussed in the following write-up in relation to the purchase spec measurements. The problems are grouped in categories that caused troubles so that areas of needed improvement are easier appreciated. The categories are components, video processing, and alignment of electrical and mechanical variables. The cause of the many variations seen in the pictures required analysis and measurements of performance variations in order to form conclusions and simply state the causes that are summarized below:

COMPONENTS

1. Lens

Problem 1 - Resolution

The resolution of any lens gradually decreases as the iris is opened because more lens area away from the center axis is brought into image forming use. It was found that the resolution of all the lenses used by the

camera companies did not pass the minimum resolution specified in the spectrum specified. Some of the lenses degraded below camera resolution specified at minimum f stop in a narrow-light spectrum.

Correction - The camera companies applied incoming vendor inspection to identify and reject defective lenses.

Problem 2 - Spot Geometry and Density Gradient

To make possible a large f stop range (300:1) with a normal iris movement, a variable gradient, neutral density spot is applied to the center of the lens. Two faults result in camera performance when the spot is not at the center of the mechanical iris and when the symmetry of the spot is out. The first fault produces large shading in the picture at large f numbers. The second fault causes iris instability or oscillation because of reversal in light control.

Correction - Incoming vendor inspection.

Problem 3 - Focus

The focal plane of an uncorrected lens moves with frequency; color shade. Lens corrections of varying amounts are applied to lens elements to minimize the focal plane shift. The lenses used by the camera manufacturers were only corrected to an acceptable amount over the visible spectrum between 300 and 800 nanometers. However, the vidicon responds on out into the IR region to 1100 nanometers.

There is a rapid shift of the focal plane of the camera lens as the imaged radiation moves into the IR. This causes a decrease in resolution because the IR image is out of focus.

It was found that none of the lenses used on the cameras could meet the advertized resolution when scenes were illuminated by a tungsten 2850°K light source. A lens corrected over the vidicon spectrum is very expensive and out of the price class of the camera.

Correction - The purchase specification was relaxed so that camera resolution could be accepted with a spectrum only in the visible range. Sensitivity requirements were left unchanged, and they depend on the radiation over the full vidicon spectrum. However, to simplify testing, wide spectrum sensitivity measurements are made using visible light. Appendix B is a memo on changing camera sensitivity with illumination spectrum. A cool white florescent light is used for testing which has an intensity of five times the intensity of 2850°K light as measured by a standard optical photometer. The iris openings and Automatic Gain Control (AGC) settings can be made as well as resolution checks without changing the light source.

Filters that reject IR were obtained and tested on a few cameras for another possible solution. The filters increased daylight resolution by rejecting IR and they did not effect night time resolution or sensitivity since high pressure sodium night illumination of the fence line contained little IR. The filter

cost is $100 in small quantities. It is on glass, sized to replace the camera window in the environmental housing. New cameras may use smaller, less expensive filters as an additional lens element. Their use will enhance camera performance in daylight without reducing night time sensitivity so long as low percentage IR illumination is in use.

Problem 4 - Mechanical Shock Resistance

The original mechanical support of the lens was not adequate to keep the lens assembly from breaking loose in normal shipment and rough field handling.

Correction - The support was strengthened for better lens support.

2. Vidicon

Problem 1

Maximum (limitting) resolution of some vidicons was below specification.

Correction - Incoming inspection test and rejection of out-of-spec vidicons.

Problem 2

Unwanted visible patterns and excessive noise in the video when face plate light level is below 0.05 FC. This is caused by inferior face plates having flaws and poor sensitivity. Only RCA vidicons contained consistently high quality face plates.

Correction - All manufacturers except RCA claimed that their vidicons are not intended for operation below 0.05 FC. Therefore, only RCA vidicons can be used in the cameras to meet specifications.

VIDEO PROCESSING

This consists of the functions performed by the following sub-sections:

1. Pre-Amp
2. ALC; Iris Drive
3. AGC Amplifier
4. ALC/AGC Control Function
5. Black Level Clamp
6. Black and White Peak Clippers

7. Gamma Control

8. Vidicon Control

1. Pre-Amp

a. The pre-amp must be a low noise design so that noise originating in the vidicon is predominant. The signal from the vidicon face plate is very low. The beam current in dark conditions is a few nanoamperes. Using a good vidicon with a low noise amplifier, a normal P-P signal to rms noise ratio is $>$36 db with 0.05 FC highlight illumination on the face plate. Broadcast Quality Pictures show $>$ 52 db ratio. With 0.005 FC illumination, the specification allows a S/N ratio of $>$ 16 db with 200 lines of resolution. Good vidicons and pre-amps give S/N ratios of around 25 db with 0.005 FC and 350 lines of resolution. Less bandwidth reduction can be tolerated to keep the resolution to at least 350 lines. Hence, to keep picture quality high, future specifications should define the better performance.

b. The bandwidth of the pre-amp must be held to 10 MHz to insure that the pre-amp does not limit resolution. In a Nation Television Standards Committee (NTSC) signal, 1 MHz allows for 80 lines of resolution. Hence, 10 MHz will resolve 800 lines.

c. The pre-amp must operate with short spike overloads in the video signal and recover with minimal lag. There must be no tails or streaks in the picture.

d. The voltage transfer function of the pre-amp must be linear so that the gamma of the camera (light to voltage transfer) is not effected by the signal level from the vidicon.

2. ALC; Iris Drive

The iris stop controls the illumination on the vidicon face plate. The face plate light level must remain near the operating midrange of 0.05 FC.

The photosensitive image tube has a near linear light vs. voltage transfer curve over a rather narrow light intesity range. The dynamic light range is more restrictive than that of photographic film. In the vidicon, the intensity range is only about 30:1 allowing 10 shades of test gray where the ratio between shades is $1:\sqrt{2}$. All shades in the range above and below the 30:1 ratio are reproduced as white or black. Background lighting on the fence line has been designed to restrict the variations to 8:1. The more even the fence line illumination, the less shading there is in the picture. With an 8:1 ratio, there is still a range of two test gray steps (2:1) for contrast changes above and below the darkest and lightest areas in the scene.

The iris drive motor or solenoid must produce enough torque to prevent mechanical sticking of the mechanism. The drive must move the iris from open to closed or reverse in less than 5 seconds. This speed requires the use of spot filters. The mechanical iris of the lens of the cameras was not designed for almost continuous movement as required by outdoor light changes. However, in

several years of use the iris did not fail but the motor drive/gear attachment that was added to the lens did come loose, disengage or bind up many times.

3. AGC Amplifier

The bandwidth, linearity and overloading characteristics of the AGC amplifier must be optimized as gain varies 20 db. Observations have shown that video bandwidth carrying a noisy picture can be reduced to improve the apparent picture quality. That is, the bandwidth may be reduced to the equivalent of the resolution showing through the noise. The NAVAIRDEVCEN specification allows a reduction to 2.5 MHz. However, it has been found that picture noise at low light using present vidicons is lower than anticipated and a reduction to only 3.5 MHz can be allowed.

4. ALC/AGC Control

The iris setting and the AGC gain are both controlled by a simple function of the video signal from the scene being imaged. The problem of processing the video to obtain a suitable control function is made difficult by the fact that the area of interest within a scene is never known until after the fact. However from much testing, it has been found that the iris and gain can be controlled satisfactorily by the Average Picture Level (APL) of the whole scene times a constant when the APL ranges between 20 and 80 percent. An example of the control problem is that extreme APL levels of the whole picture are possible when the average level in the area of interest in the scene remains constant.

The APL of normally lighted fence scenes is around 50 percent. However, when the sun reflects from bright wire, glass or metal, local very bright spots are made, or when car headlights are in the scene at night, peak light levels go high and the APL is high. Under these conditions, the vidicon will be overloaded at peaks and white peaks probably will be clipped. The APL will be higher than normal and if iris corrections are not applied, the iris setting will darken all but the bright areas of the scene. It has been found that when the camera output is allowed to change 100 ± 10 percent as the APL changes between 20 to 80 percent (50 ± 30 percent) satisfactory scene contrast in the areas of interest results in about 95 percent of the problem conditions. This control function is a great improvement over the original peak video detector function that controlled the output of early cameras.

5. Black Level Clamp

Changes in scene APL cause a-c coupled black levels in the video signal to shift relative to ground. The vidicon steady state current at zero light level (dark current) increases with high environmental temperature and tube age; hence, this current change is another cause of black level shift.

To maintain the best contrast without the necessity of the observer adjusting the picture monitor, the darkest areas of a scene must always be near the cut off of the monitor. In addition, this action gives automatic contrast enhancement to low contrast scenes because the most gray areas are forced to black.

For good performance, the black level clamp circuit must hold the black in the video to 7.5 ± 5 IRE units. One volt equals 140 IRE units. The General Electrodynamics Corporation/Arvin Corporation (GEC/ARVIN) camera uses a high performance black clipper and clamper that performs very well under all scene conditions. The Cohu control attempts to compensate the black drift as a function of the steady state vidicon beam current change. The operation of the circuit is very poor with APL changes and it allows much drift that is a function of visible to IR ratio in the scene spectrum. The Cohu control has been improved because of measurements by NAVAIRDEVCEN; (Appendix C, letter to Cohu dated 6 October 1978) but the performance may never equal Arvin because of the design approach.

6. Black and White Peak Clipper

The positive and negative video clippers are biased diodes. The clippers are after the clamped video and there is little trouble with the design. Performance troubles experienced are caused by improper adjustments at the factory during camera alignment.

7. Gamma Control

The gamma in a TV camera is a characteristic measurement started by the film industry with the development of movies. It is a measure of the expansion or compression of the shading in a scene to the shading in the reproduced picture. The transfer expression is:

$$e_{in} = e_{out}^{\gamma} \text{ where the exponent, } \gamma \text{, is called gamma.}$$

The vidicon, pre-amp, AGC amplifier and peak clippers have normal gamma values near 1 and must remain unchanged over the signal operating ranges. The video system gamma correction is made in the camera using an adjustable gamma correction circuit to maintain a uniform transfer function. Gamma is adjusted to 0.7 with controlled scene and camera test conditions; APL 50 percent, AGC gain 1 and black level set to 7.5 IRE units. With gain and black level controlled by closed loops, the gamma of the camera is only a fixed value in known scene conditions.

A gamma of $<$ 1 expands the shading in the darker areas of a picture. It has been found that a gamma value of 0.7 will improve the ability of an observer to distinguish objects in dimly lighted areas of night scenes without producing an abnormal looking picture in daylight. It is interesting to note that the movie industry uses gamma values $>$ 1 to improve contrast in bright areas of a picture.

8. Vidicon Control

With fixed voltages on the vidicon, temperature and tube aging cause the steady state beam current to change. Environmental conditions do cause the beam current to drop from its set up value and the picture is "wiped off" from a beam starved condition. Manual beam current adjustments must be performed by maintenance to restore camera operation. A regulator has been added to automatically control the current at the set up values. This feature allows the camera to operate without a sun shield. The picture will never "wipe off" until the vidicon becomes old and loses emission.

Focus coil current regulation also is provided to maintain sharp focus under all conditions for the life of the tube.

ALIGNMENT OF ELECTRICAL AND MECHANICAL VARIABLES

The analog circuits in the automatic TV cameras require critical adjustments by skilled technicians in order to obtain reasonable performance from the camera. The following information is included to present the care in alignment needed in present commercial design. Subsystem operating ranges must be carefully set into the camera.

It was learned that camera alignment technicians do not completely understand the techniques needed to set the variable parameters because of the large interaction between adjustments. The adjustments of the older, nonautomatic cameras they align are not as interacting. Also, final adjustments are made in the users area for "best picture". The factory technician was skilled in making adjustments for a picture but test equipment and instructions are lacking to insure specified values on performance. These facts will change with experience but they must be considered now as a cause for out of specification performance on cameras delivered to and rejected by NAVAIRDEVCEN.

The following electrical alignments must be accurately adjusted to obtain uniform camera performance. Specified values are with a RETMA test chart, 50 percent APL. The APL is changed by darkening or lightening sections of the chart.

1. ALC; iris setting - wide open iris at 0.05 FC.

2. AGC setting - X1 gain at 0.05 FC
X10 gain at 0.005 FC

3. Output video level with 0.05 FC - 100 IRE units

4. Sync level 40 IRE units

5. If 1, 2, and 3 are correct, video output will remain constant at 100 IRE units when level on face plate is between 0.005 FC and scene level to 10,000 FC. Output will be 100 ± 10 IRE units when APL changes between 20 and 80 percent at all light levels.

6. Black level clamp - set level to 7.5 IRE units, operating limits ± 5 IRE units.

7. White peak clipper - set to 120 IRE units.

8. Gamma - adjust system for 0.7; use RETMA test chart, AGC gain x 1 and check gamma when gain X10.

9. Hi freq peaking - adjust for maximum (700 lines) resolution with no following whites or blacks.

10. Raster size - beam current is set just above picture "wipe-in", electrical focus "best" over scene, mechanical focus at infinity for open iris, then H&V size set for correct size for lens on camera and no trapezoid.

Mechanical adjustments are few. The most critical for causing a degraded picture are as follows:

1. Vidicon tube must be seated into the face plate socket and the neck clamp tightened to prevent tube movement.

2. Lens set for infinity focus and checked with wide open iris. All adjustments allowing focus change must be tightened.

3. "O" ring seals between the camera and environmental case must be clean and coated with grease, camera lock set, glass window clean and snap rings properly installed. If camera case is not air tight, breathing causes moist air to fog window.

APPENDIX A

CAMERA SPECIFICATIONS

1. Electrical Input and Output Requirements
2. Imaging Characteristics
3. Mechanical
4. Environmental
5. Auxiliary

CAMERA SPECIFICATIONS

1.0 Electrical Input and Output Requirements

1.1 Power - Camera shall operate from 115 V AC, 60 Hz power source and camera performance shall be as stated in the specification over a voltage range between 105 V AC and 125 V AC.

1.2 Load Impedance - of the camera video output shall be 75 ohms. The output shall be connected for single ended, unbalanced operation. ALC operation shall be independent of output termination.

1.3 Level - Camera output shall be composite video of 100 IRE units video and 40 IRE units sync. 140 IRE units equals 1 V P-P.

1.4 Polarity - Picture video output shall be black negative.

1.5 Sync

1.5.1 The composite sync waveform shall be as specified in EIA standard RS-170. The picture shall be 525 lines per frame, 60 fields per second and positive, 2:1 line interlace.

1.5.2 Sync amplitude at the output shall be 40 ± 1 IRE units measured below the blanking level.

1.5.3 Camera sync signal shall be an eternally generated EIA RS-170 waveform. A genlock option will enable the sync frequency to be free running or automatically locked to an external RS-170 composite video or sync signal if the external sync amplitude is within the range of 0.3 to 4 V P-P. The external sync line shall be single ended and termination shall be selectable between 75 ohms or a high impedance for loop through operation. Internal connections shall permit locking the camera sync to the power line frequency or to a crystal oscillator.

2.0 Imaging Characteristics

2.1 Camera Tube Type - Low Blooming Silicon Diode Array Vidicon

2.2 Geometric Distortion

2.2.1 No picture element shall be displaced from its true position referred to the subject by more than 2 percent of the picture height.

2.2.2 Width to height aspect ratio shall be 4:3.

2.2.3 The H&V amplitude of the image tube scan shall be adjusted so that when a 4;3 frame, sized for the lens, is focused to the nominal 16 mm diagonal on a 1 inch image tube faceplate, the frame will edge the raster on the monitor within ± 1.5 percent.

2.2.4 Picture tube shall be protected from spot damage by H&V scan failure sensing circuits to blank the beam.

2.3 Sensitivity and Dynamic Range

2.3.1 Face plate illumination shall be referenced to 2854°K tungsten light.

2.3.2 A nominal 0.05 fc highlight illumination on the faceplate shall produce 100 IRE units of picture video output. The rms noise at the output with 0.05 fc shall be $\leq$ 0.011 rms volts; S/N $\geq$ 36 db.

2.3.3 A nominal 0.005 fc highlight illumination on the faceplate shall produce 100 IRE units of picture video output from a 10:1 (20 db) video gain increase from AGC action. The rms flat noise with 0.005 fc shall be $\leq$ 0.011 rms volts; S/N $\geq$ 16 db and resolution shall be greater than 200 lines at center of picture.

2.3.4 ALC and AGC shall maintain highlight video output at 100 $\pm$ 10 IRE units when focused on a fixed APL (Average Picture Level) test chart of 20 percent white, 80 percent black and highlight ranges between 10,000 fc and a minimum that gives 0.005 fc on to the faceplate.

2.3.5 ALC and AGC shall maintain highlight video output at 100 $\pm$ 10 IRE units with APL between 0.2 and 0.8 in a constant highlight level > 0.005 fc on the faceplate.

2.3.6 ALC response of fixed focus lenses shall stabilize the video level within 5 seconds after a change in light between maximum and minimum.

2.3.7 Video black level shall be maintained at a setup level of 7.5 $\pm$ 5 IRE units, with $\geq$ 10 percent black area in the scene.

2.3.8 Blanking level shall be a fixed reference at or near OV.

2.3.9 White peaks - Bright going video white output peaks shall reach a level of at least 120 IRE units before clipping.

2.3.10 Black peaks - Dark going video output peaks shall be clipped to prevent them from going below blanking level by < 5 IRE units.

2.4 Resolution - When the faceplate highlight illumination is 0.05 fc, horizontal resolution shall be greater than 700 TV lines per raster height near the center of the field of view and greater than 500 in the corners.

2.5 All ten gray scales on the RETMA test chart shall be discernable with 0.05 fc highlight illumination on the faceplate.

2.6 Gamma correction shall be 0.7 and internally selectable to 1.

2.7 Vidicon filament voltage shall be regulated to increase filament reliability and life.

2.8 Vidicon beam current shall be automatically controlled to prevent an image "wipe-off" condition.

3.0 <u>Mechanical</u>

3.1 The camera shall be contained within one case and the connector(s) for power input, composite sync or video input and composite video output shall be selected to minimize corrosion due to electrolytic action between dissimilar metals.

3.2 The camera case shall be provided with a mounting base that has at least two mounting holes drilled and tapped in the bottom. The holes shall be tapped for 1/4 - 20 threads.

3.3 For maximum ruggedness and minimum size, the camera and lens shall fully utilize the rigidity of the case for strength and resistance to shock and vibration. The camera shall be self-supporting and operable when removed from the case. The case and window shall be of rugged construction to maintain shape and mechanical stability when subjected to rough handling or impact by sharp objects.

3.4 The camera case shall be fitted with a standard Schrader valve and shall be pressurized with dry nitrogen to approximately 5 PSIG. The leakage rate shall be designed to be in the order of magnitude of 10^{-4} cubic inches per hour at 20 PSIG.

3.5 The camera window shall not degrade the resolution capability of the camera and shall be nonreflective coated.

3.6 Case depressurization must be automatic so that the camera or camera window can not be removed from the case when the case is pressurized. A pressurization warning decal shall be visible.

3.7 The camera shall be equipped with electrical heating elements, thermostatically controlled to turn on when the internal temperature drops to $\leq$ 60°F. The heat developed will keep grease soft in the iris drive mechanism and keep moisture from condensing on the case faceplate over the specified operating environment of the camera.

3.8 The camera shall be capable of being equipped with optical sub-assemblies incorporating lenses with focal lengths of 12.5, 25 and 50 mm at F1.4, 75 mm at F1.8 and 16-160 mm zoom at F1.8. The lens assembly shall be enclosed within the pressurized camera case.

3.9 All fixed focal length lenses shall be set to infinity focus with the iris wide open.

4.0 <u>Environmental</u>

4.1 The camera shall be operable or storable without damage for the environmental ranges specified in this section.

4.2 Temperature: -40 to +60°C, storage -62 to 85°C.

4.3 Humidity: to 100 percent.

4.4 Vibration: 5 to 30 Hz total excursion 0.03 inches, 30 to 1000 Hz peak random vibration of 5 g.

4.5 Shock: 15 g's. along any axis if not operating.

4.6 The camera and lens shall have the protection provided by the pressurized case against sand and dust, fungus, salt atmosphere and explosions.

5.0 Auxiliary Information

5.1 Operating and Maintenance Manual for each camera shall be supplied. The manual shall contain the following information:

Operating instructions

Maintenance instructions

Schematic Diagrams

Circuit description

Replacement parts list

Warranty instructions

5.2 The lens type shall be specified in the schedule.

5.3 A typical MTF (Modulation Transfer Function) curve for the camera type shall be supplied. Sine or square wave response measurements are acceptable for a typical transfer function with 0.05 fc highlight illumination on the faceplate.

5.4 A mating connector shall be provided for each camera connector.

APPENDIX B

TV CAMERA SENSITIVITY WITH CHANGES IN ARTIFICIAL ILLUMINATION

TV CAMERA SENSITIVITY WITH CHANGES IN ARTIFICIAL ILLUMINATION

Camera manufacturers specify camera sensitivities in lumens on the faceplate per unit of video output. A lumen per square foot or foot-candle is a universal, readily measured unit but it expresses the intensity of only visible wavelengths. Because the silicon diode array vidicon image tube in the physical security camera is sensitive to radiation outside the visible band (800 to 1100 nanometers) as well as in the visible band (300 to 800 nanometers) there is need for radiation measurement or control over the entire vidicon response band. Control is accomplished by standardizing the source spectrum as tungsten with a color temperature of 2850°K. This spectrum is nearly equal to the sun spectrum over the vidicon band.

However, when a camera images with radiation from gas tube artificial lights, the source spectrum infrared distribution is very different from that in the standard spectrum.

When spectral distributions of light sources are not known, misunderstandings about sensitivities of cameras operating in the light sources are common. Complicated corrections must be applied to the manufacturers claimed sensitivity in order to state lamp intensity of artificial light for a unit of video output. This is because there is no universal measuring unit that expresses the radiation intensity of the total vidicon band. Universal units such as the foot-candle measure only an intensity in the visible band. In order to adjust the sensitivity of the camera from the specified to a new value in artificial light, a correction is applied that requires a knowledge of the spectral characteristics of the light source, photometer and vidicon.

The spectral characteristic of an artificial light source through the band beyond the visible is difficult to obtain. The information is of no interest in normal lighting needs and extended range spectrum analyzers are not available in lamp manufacturing R & D labs.

The spectral characteristics of the vidicon are always published as part of the vidicon specifications.

Photometer spectral characteristics are also published as part of the specifications and the response is tailored to match that of the eye.

By calculating the response ratio of photometer to camera, one is able to state the relative response of the photometer and camera in any given light source.

$$\text{Response ratio} = \frac{\text{matching factor of photometer}}{\text{matching factor of camera}},$$

where the matching factor is the ratio of sensor output in the light source to output if the sensor response matched the light source spectrum distribution. Stated another way, the sensor product curve area divided by source curve area.

$$\text{Matching factor} = \frac{\int_0^\infty \text{(normalized sensor response) (source spectrum)}}{\int_0^\infty \text{source spectrum}}.$$

By ratioing the response ratio in an artificial light spectrum to the response ratio in a standard spectrum one has the lumen or measurable intensity ratio from the claimed sensitivity that will maintain equal video from the camera.

$$\frac{\text{response ratio (artificial light)}}{\text{response ratio (standard spectrum)}} = \frac{\dfrac{\text{photometer (A)}}{\text{camera}}}{\dfrac{\text{photometer (S)}}{\text{camera}}} = \frac{\text{photometer (A)}}{\text{photometer (S)}}$$

Examples of relations that have been calculated based on known spectral distributions are contained in table A-I.

The data shows that for a photometer reading of one unit in 2850°K tungsten light and a vidicon output of one unit the following photometer readings are necessary in artificial lights to maintain one unit of vidicon output.

LAMP	PHOTOMETER	VIDEO
2850°K Tungsten	1.0	1
High Pressure NA	2.6	1
Low Pressure NA	6.1	1
Multivapor	3.4	1
Mercury Vapor	2.0	1

The power required by each lamp for the intensity needed to maintain one unit of output is as follows:

LAMP	POWER	VIDEO
2850°K Tungsten	1.0	1
High Pressure NA	0.47	1
Low Pressure NA	0.68	1
Multivapor	1.0	1
Mercury Vapor	0.86	1

Therefore, the high pressure sodium lamp uses less than one-half the power and the visible intensity is 2.6 times that of a tungsten lamp to maintain the same video output from the silicon diode array vidicon. It is the most efficient lamp available for scene illumination for the physical security TV camera.

TABLE - A - I

SUMMARY OF CHARACTERISTICS OF VAPOR LAMPS
COMPARED TO A TUNGSTEN LAMP AND EQUAL
VIDEO LEVEL FROM A SILICON DIODE VIDICON.

LAMP TYPE	TUNGSTEN	HIGH PRESSURE SODIUM	LOW PRESSURE SODIUM	MULTIVAPOR	MERCURY VAPOR
PHOTOMETER MATCHING FACTOR	2.6%	14.6%	23.4%	8.84%	6.24%
CAMERA MATCHING FACTOR	20.6%	44.2%	30.4%	20.7%	24.4%
PHOTOMETER/CAMERA RESPONSE RATIO	0.1262	0.330	0.770	0.427	0.256
LUMEN RATIOS NORMALIZED TO TUNGSTEN	1	2.6	6.1	3.4	2.0
LAMP RATINGS					
LUMENS/WATT	20	112	180	68	48
WATTS/LUMEN	0.050	0.009	0.0056	0.015	0.021
POWER RATIOS LUMEN RATIO TIMES WATTS/LUMEN	0.050	0.023	0.034	0.051	0.043
POWER RATIOS NORMALIZED TO TUNGSTEN	1	0.47	0.68	1	0.86

APPENDIX C

TECHNICAL MEMO TO COHU, INCORPORATED

NADC - H. Hayes
c/o Ted Boyce
Code 4054
Warminster, PA 18970

October 6, 1978

Cohu, Incorporated
Mr. Gene Crow
Box 623
San Diego, CA 92112

Dear Gene:

I have investigated the performance defect in the 2850B that I had discussed with you in August. The defect is out of specification black level conditions with offset errors of up to 50 or more IRE units depending on camera temperature and if a daylight or night scene is imaged. Varying amounts of offset errors develop in about all of the 2850B cameras sent to NADC. The magnitude of the problem was not apparent until 20 camera stations were operating in the field and pictures are switched at random to common picture and waveform monitors.

One condition causing the defect and a correction are explained as follows. Circuit and image changes cause changes in spectral content and wave shape or average video level in the AGC and black level detection bands, op amp U112 and op amp U71 respectively, apparently because the bandpasses and slewing rates are different in the cameras as delivered. It is the average levels that the AGC and black level diodes (CR112 & CR71) tend to charge the filter and this is the maximum (DC) control signal that can be developed. The gain and offset of a camera are set with the camera focused on a test image, hence the average video levels driving the diodes are at some relative condition. When the scene APL or AGC amplifier response changed, it was found that the relative as well as the absolute driving average changed. This could be corrected by resetting the black level pots for that condition.

Therefore, it was reasoned that part of the problem was due to a shift in the relative driving averages and that the shift could be minimized by making the two bandpasses and slewing rates identical.

It has been found that by reducing the black level bandpass to equal the AGC bandpass, which is already less than the low light level video bandpass roll off condition, the black level in all cameras is more consistant with offset errors caused by camera temperature changes and day to night image changes reduced.

The modification necessary to make this correction is, of course, very simple. The roll off cap, C72, of op amp U71 is increased from 10pf to 470pf, the same value as C113 in our cameras. The black level must be reset to 7.5 IRE units with the new constant in the circuit.

I hope that you concur with and/or supplement my findings. The mod makes the 2850B cameras less dependent on the use of a low dark current vidicon for acceptable performance.

In conclusion, it seems to me that an other improvement would be to drive CR71 with a positive going (white plus) input from the op amp and reverse CR71 so that the op amp feedback will not be DC biased in a different way then in U112. Granted the affect may be small, but I think it would be worth bread boarding to find out. The circuit change would be too much for our existing video boards but it may be worth a change in future cameras.

Yours very truly,

Henry J. Hayes

DISTRIBUTION LIST

	Copies
NAVELEX, Washington, DC	5
MERADCOM (NVL), Font Belvoir, VA	1
Naval Electronics Systems Engineering Activity, St. Inigoes, MD	1
Sandia Lab., Div. 1733, Albuqerque, NM	1
Sandia Lab., Div. 1754, Albuqerque, NM	1
Naval Electronics Systems Engineering Center, N. Charlestown, SC	1
DTIC	12